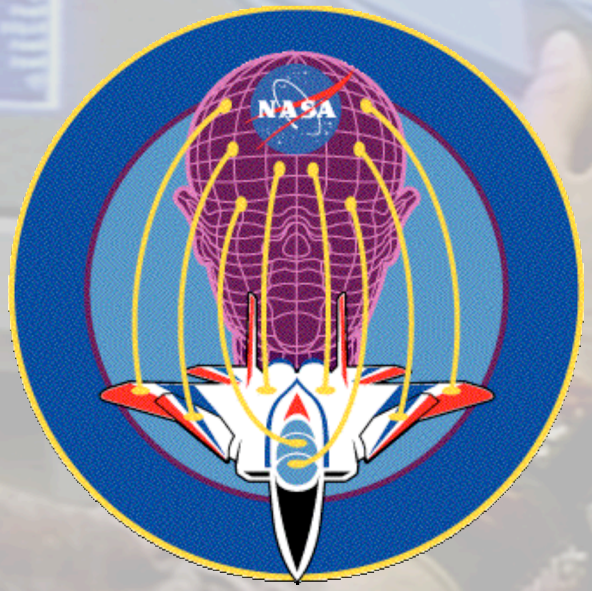
Neuro-Electric Machine Control

Overview of the Extension of the Human Senses Group Activities



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Funded by NASA CICT/ITSR/ICD/NEMC, IS/HCC, IS/IDU

Extension of the Human Senses Group

Principal Investigators:

Kevin R. Wheeler, Ph.D. – Group Lead, EMG recognition
Chuck Jorgensen, Ph.D. – Chief Scientist, silent speech, spiking neurons
Leonard J. Trejo, Ph.D. – EEG Brain Computer Interfaces

Group Members:

Mark Millonas, Ph.D.
Mark Allan, QSS Group Inc.
Charles Curry, QSS Group Inc.
Bryan Matthews, QSS Group Inc.
Shane Agabon, QSS Group Inc.
Diana Lee, SAIC
Jack Culpepper, student,
Walter Lee, student

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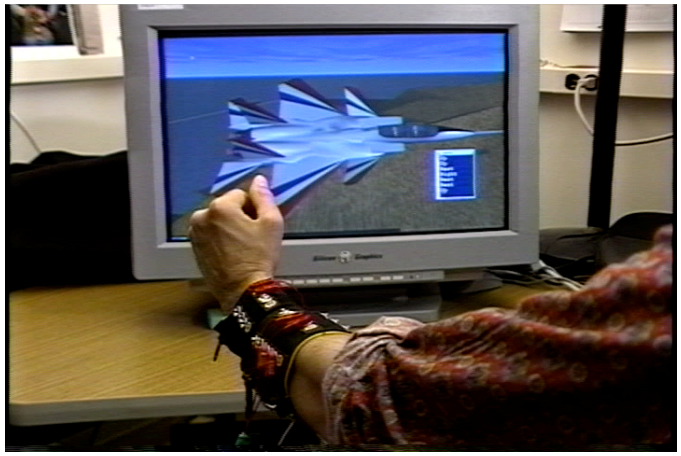
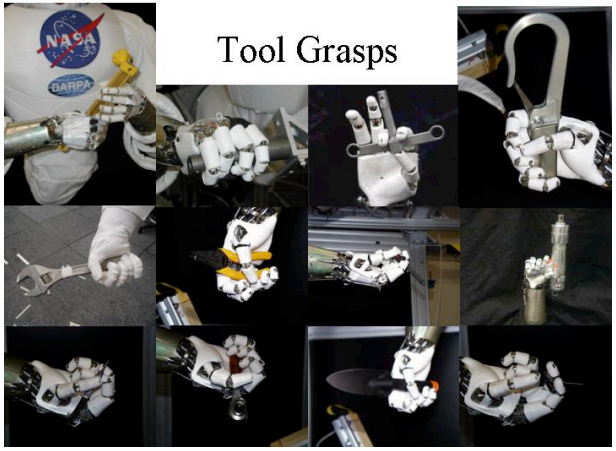
Funded by NASA CICT/ITSR/ICD/NEMC, IS/HCC, IS/IDU

Group Projects

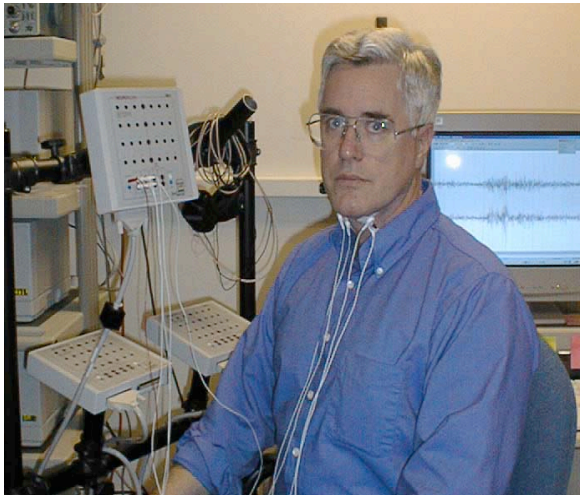
control with gestures



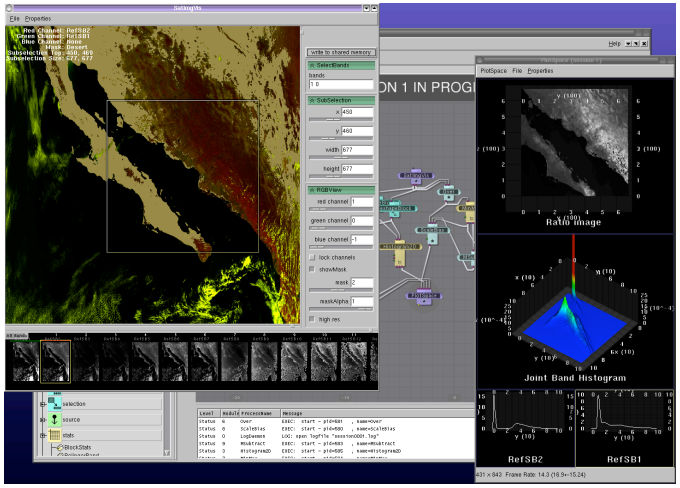
robotic interfaces
semi-autonomy



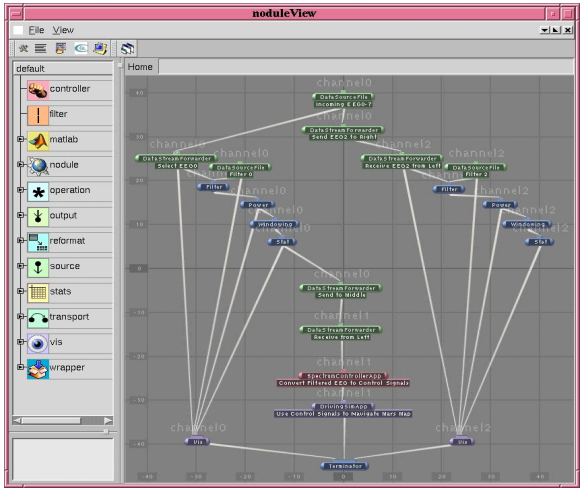
brain computer interfaces



silent speech



atmospheric inference

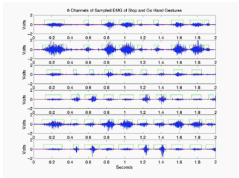


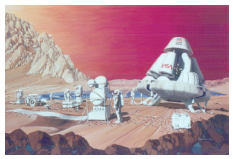
streaming frameworks

Applications

Nano Device Control

Exoskeleton Control

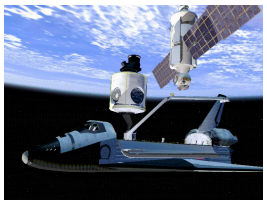




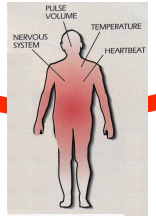
Planetary Discovery

Neuro-electric Interfaces

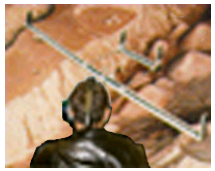
Silent Communication

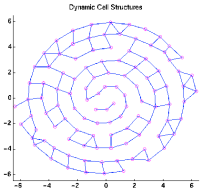


Manipulator Control



Wearable Cockpits

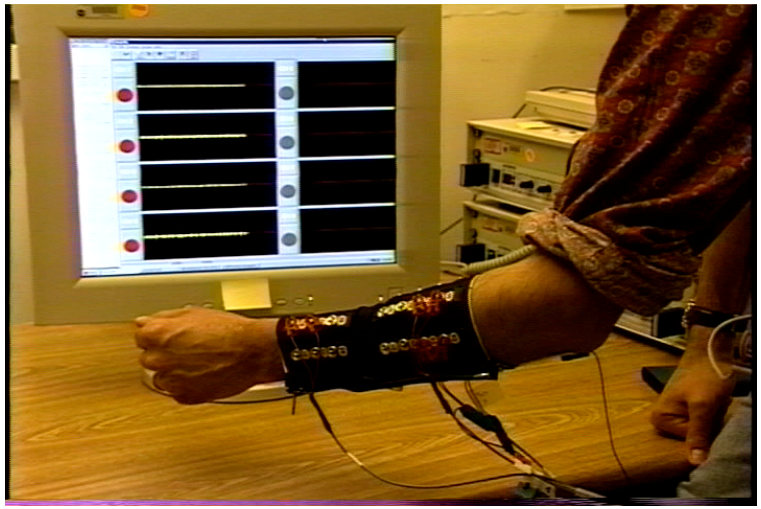


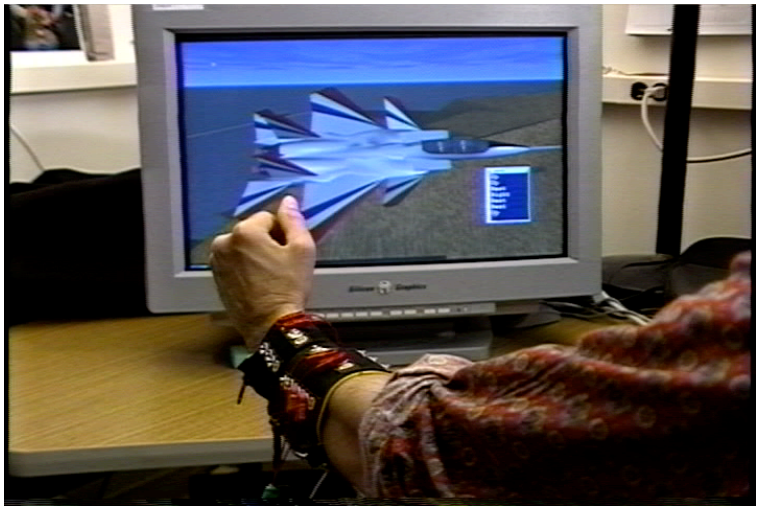


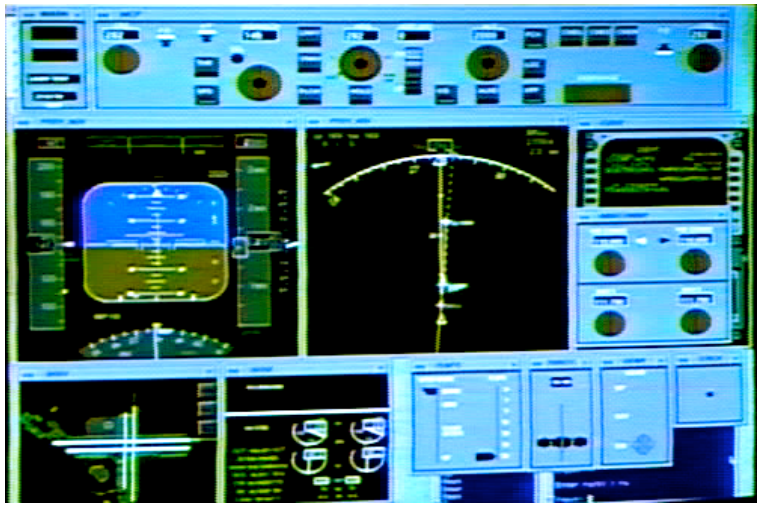
Data World Immersion

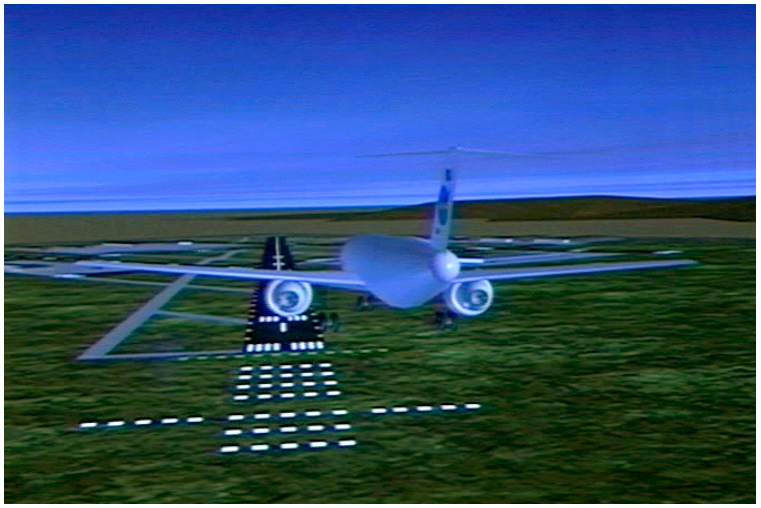
Human/Machine Communication

Output sensory mapping
Virtual joystick

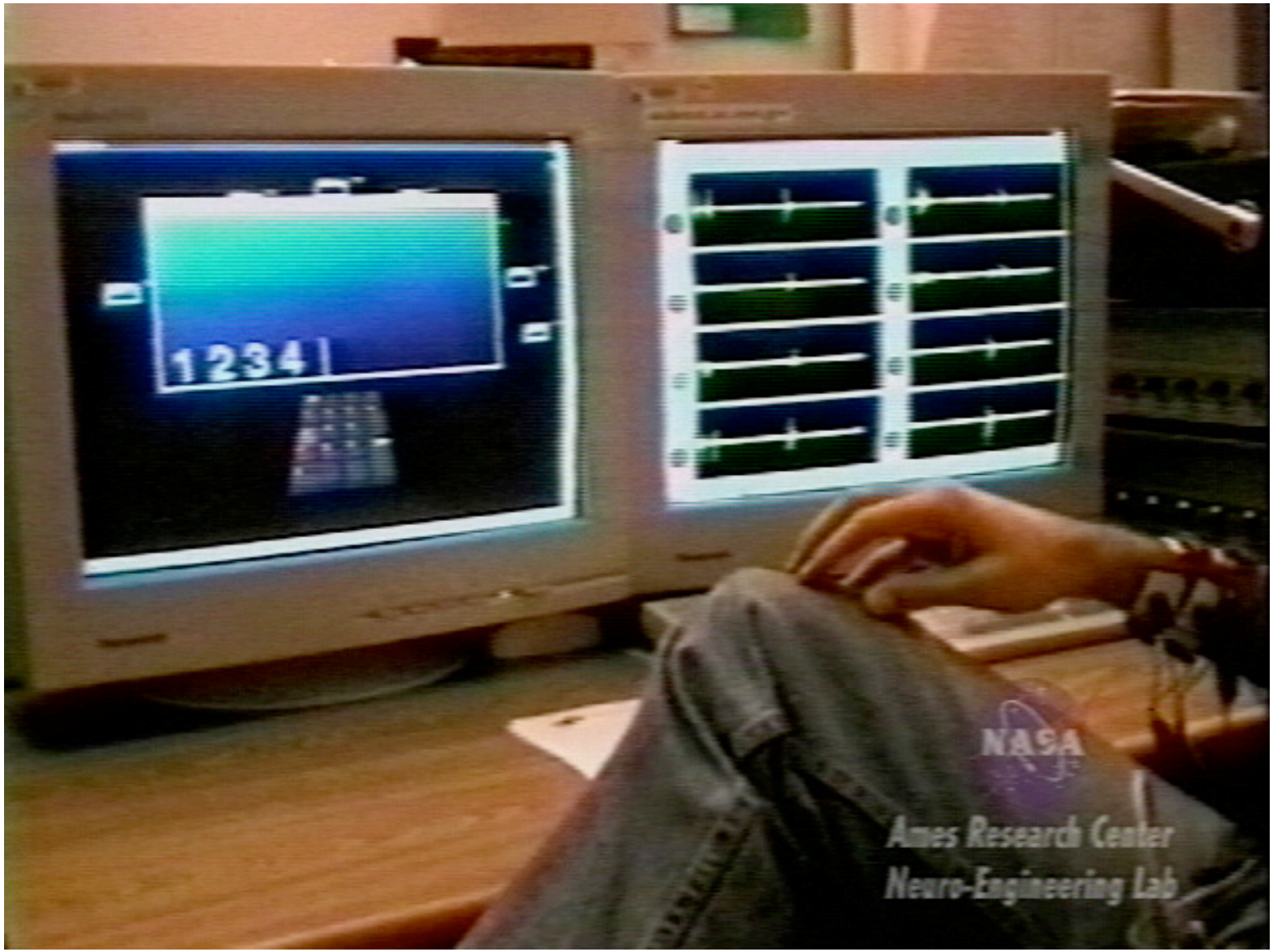




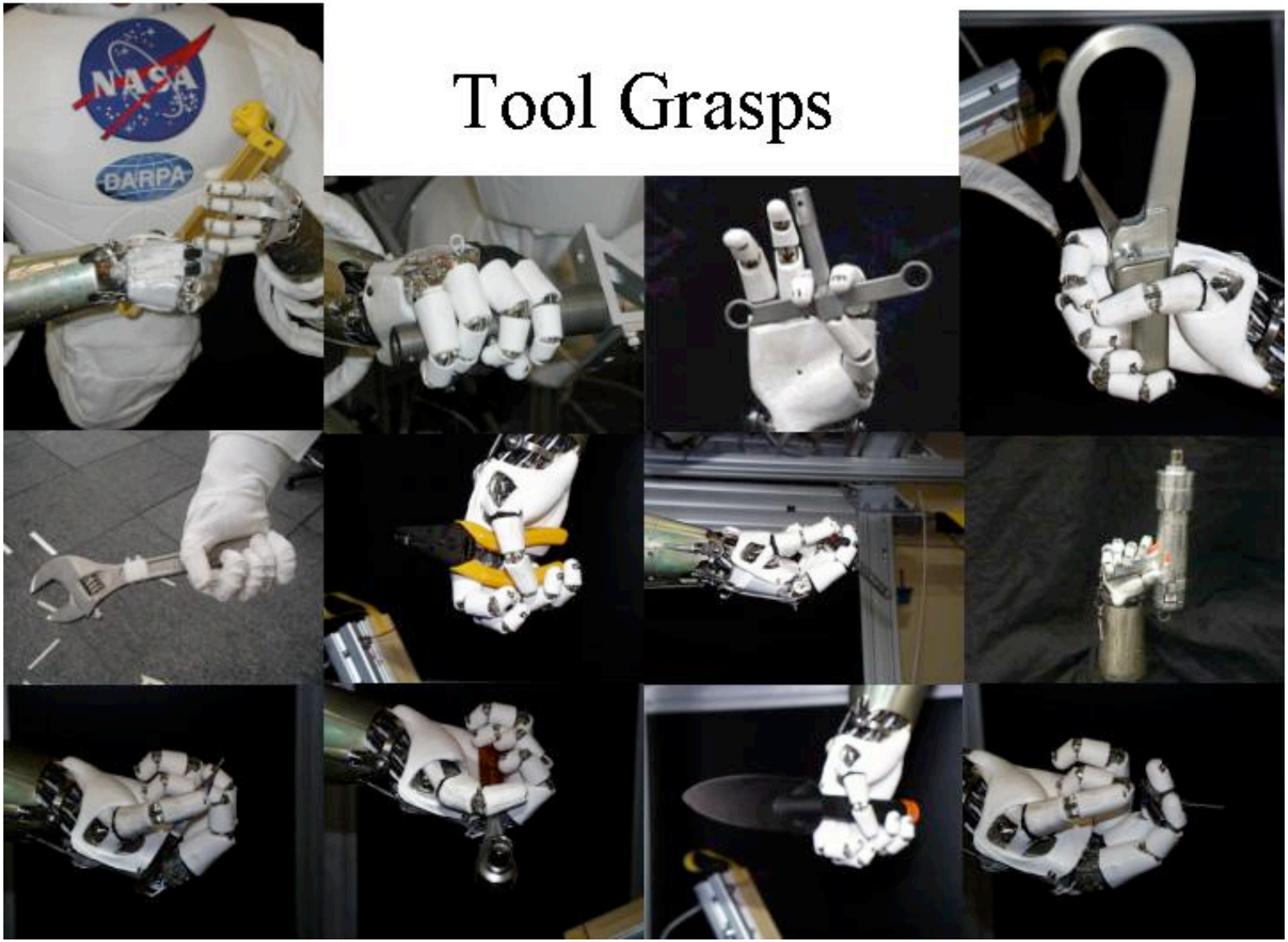




Output sensory mapping
Virtual Keypad



Gestures for semi-autonomy

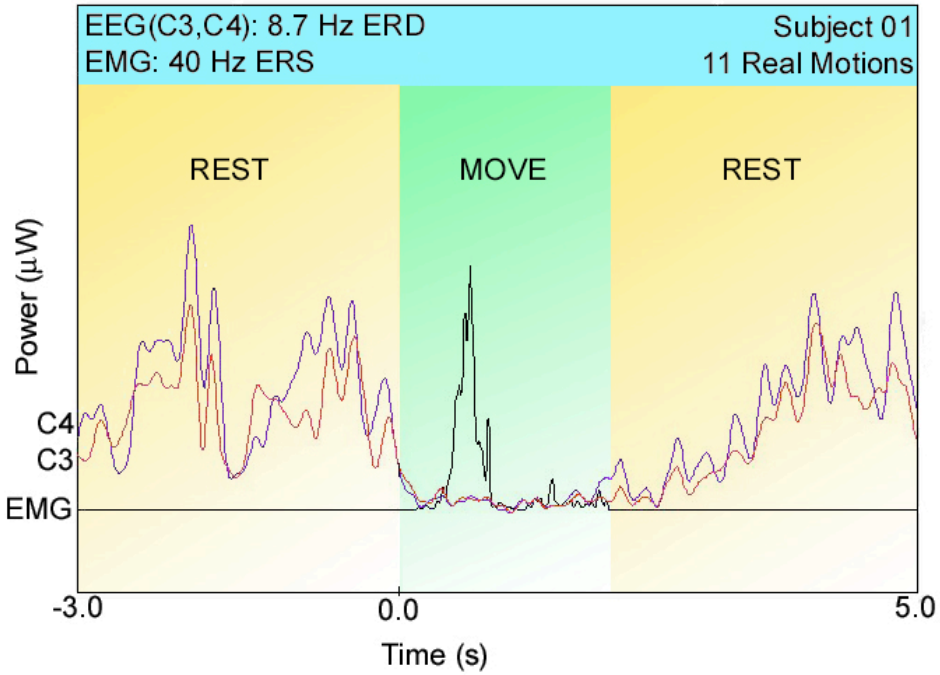


Brain Computer Interfaces

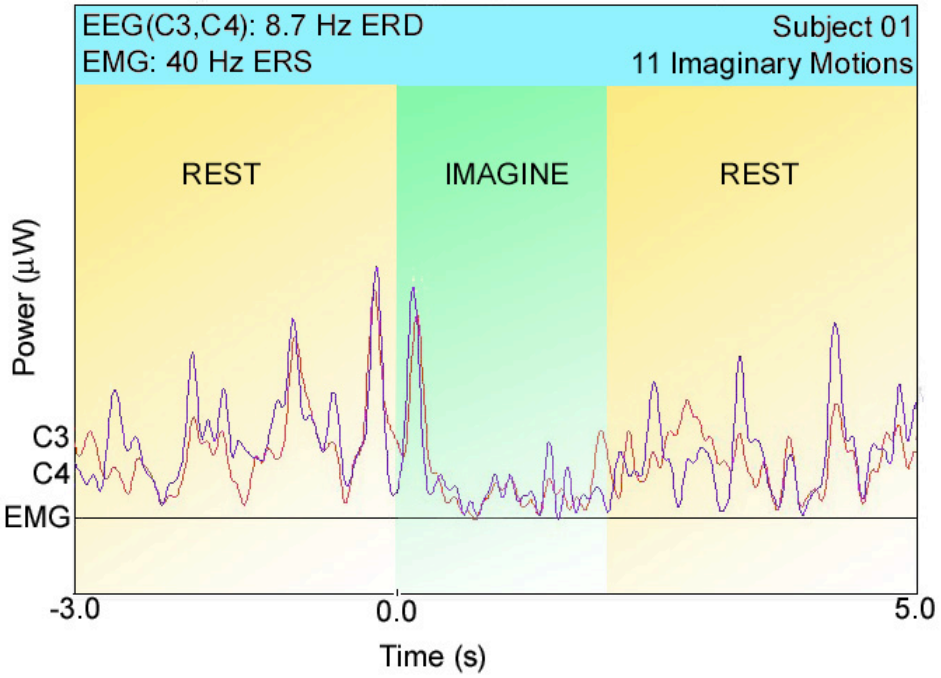
Leonard J. Trejo, Ph.D.

mu rhythm control:

Real Movement



Imagined Movement



Sensor Positioning System

64-electrode EEG signal from real-motion condition

↓

Narrow-band filter at desired frequency

↓

Select artifact-free EEG segments

↓

Spatial SVD

↓

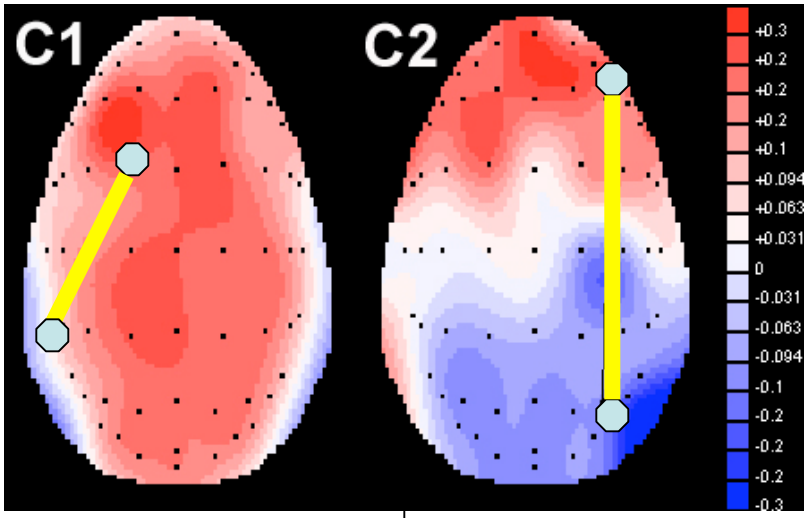
First 2 Orthogonal Components

↓

Approximate C1, C2 with 2 electrode pairs

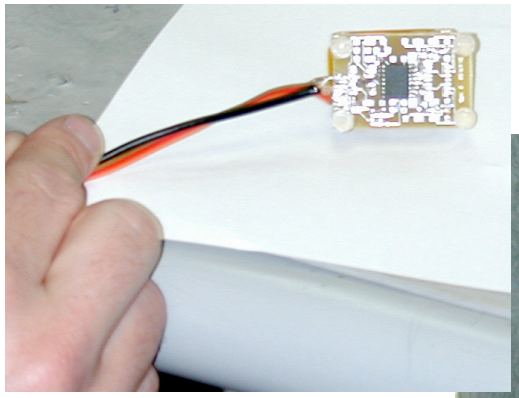
↓

Incorporate in sensor design for real-time system

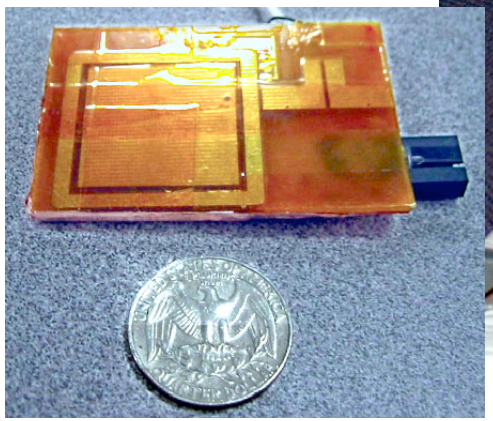


Non-contact Sensor Development

QUASAR Stacked Sensor



Eight-channel EEG plus EOG and QUASAR Sensor Recordings



Lash-up of Mini-differential QUASAR Sensor

QUASAR: Quantum Applied Science and Research Inc.

Design Goals

Near-term

- Refine non-contact technology
- E-field sensor (normal to scalp)
- Shielded room

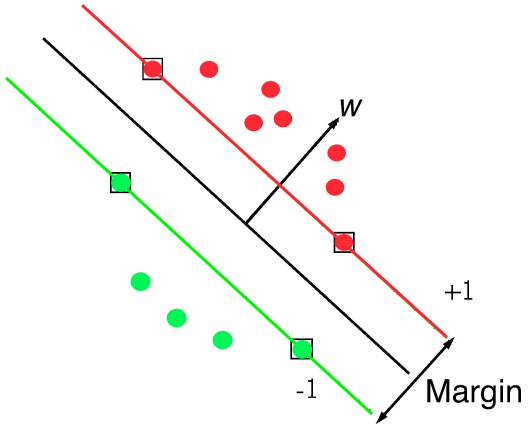
Mid-term

- Differential sensor (tangential to scalp)
- Mini sensors (2-3X smaller, thinner, with manufactured cover)

Long-term

- Unshielded room
- Multichannel

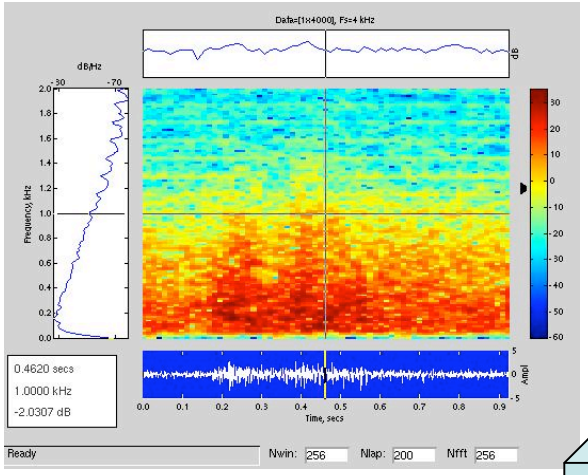
Application of KPLS and SVM



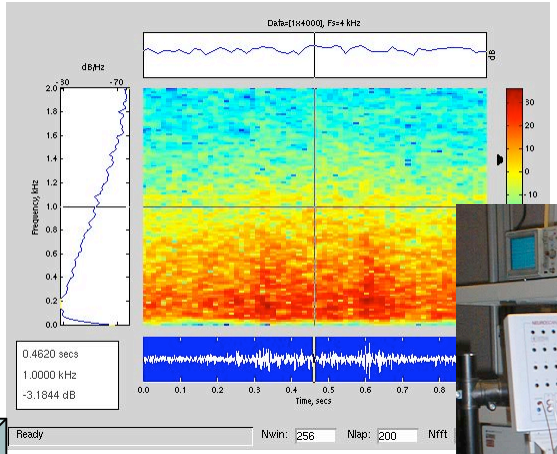
- Classification of EEG patterns associated with single-tap typing motions in three subjects
- Developed and tested a linear PLS preprocessing system
- Combined PLS system with linear SVM classifier
- PLS-SVM system detected single-tap patterns with accuracy of 80% to 95% (an increase of 15% to 30% over previous system)
- Implemented and tested PLS-SVM system in real-time framework

Silent Speech

Charles Jorgensen, Ph.D.

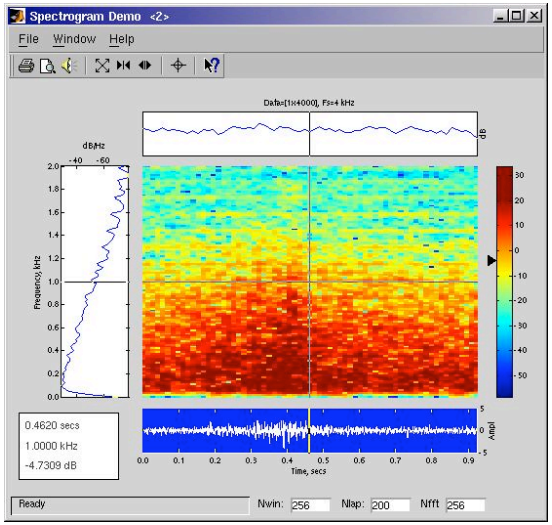


" Left "

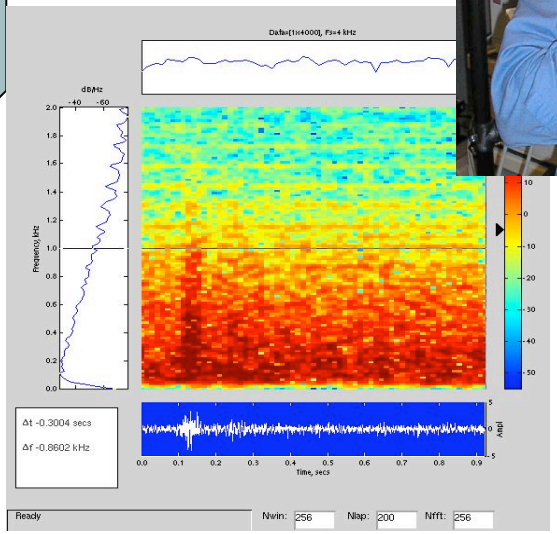


" Right"

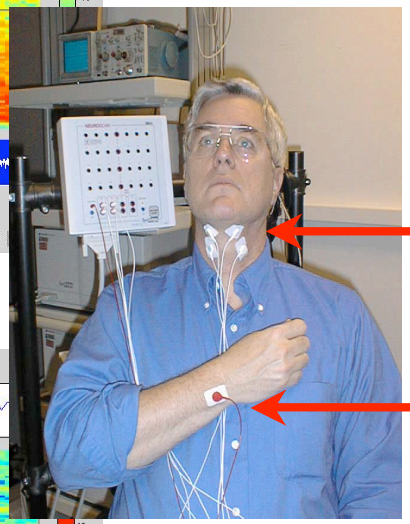
FFT



" Stop "



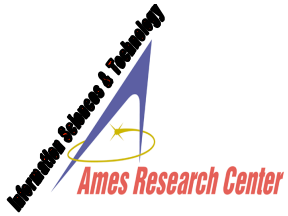
" Go "



Electrode Placement:

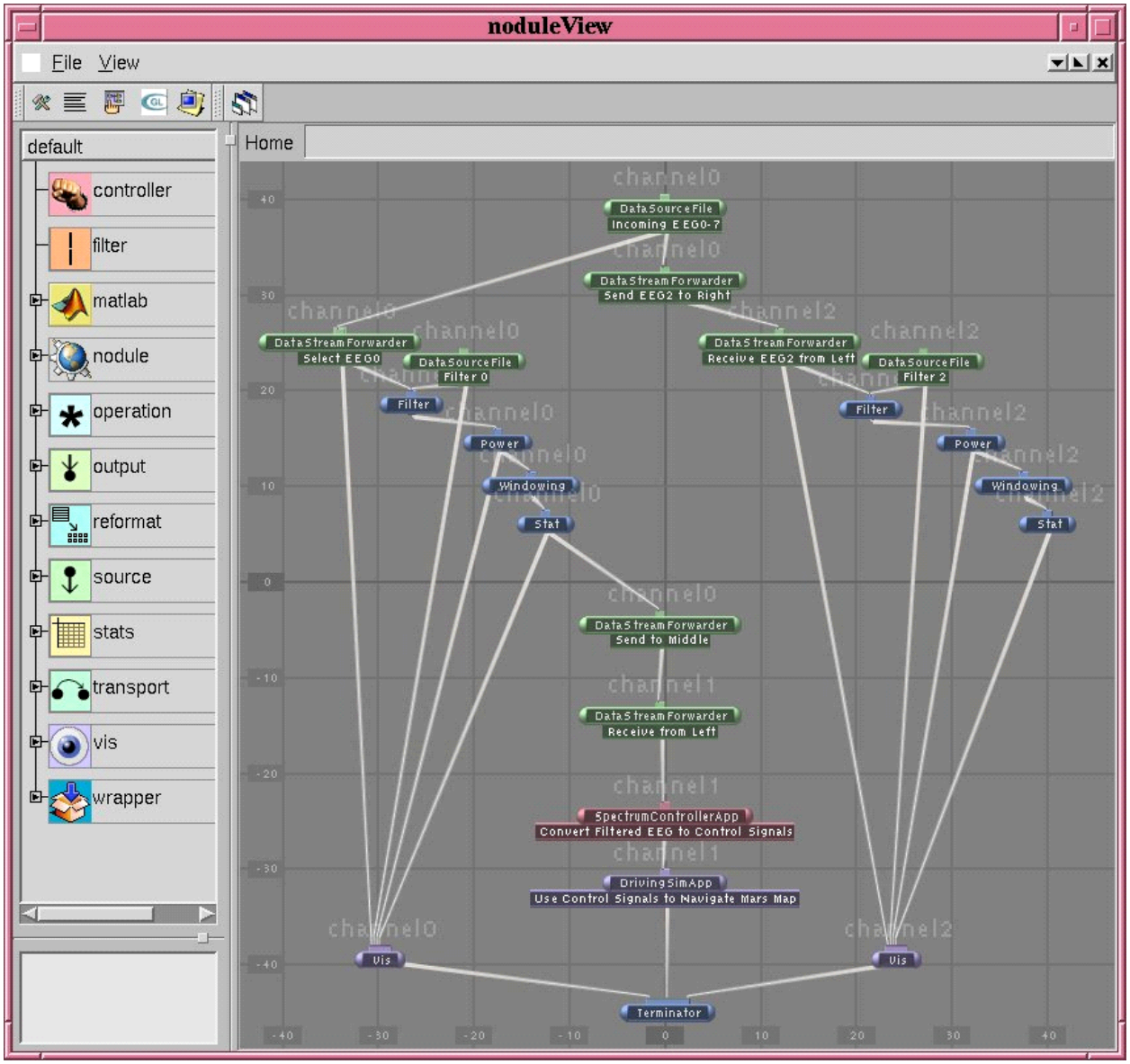
Ground

Gesture Control

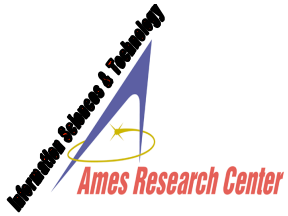


movie

Signal Processing Environment for Algorithm Development



The Need for SPEAD



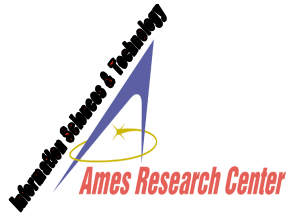
Earth Sciences –

- **data**: large, distributed, heterogeneous formats, lacking docs
- **time waste**:
  - formatting and manipulating files (80/20 rule)
  - implementing machine learning algorithms from literature for discovery tasks
  - lack of scientific method due to accessibility of appropriate forward models (need implementation using first principles)

Neurosciences –

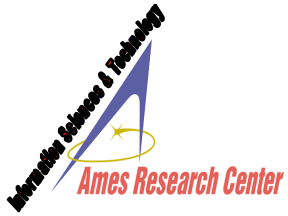
- **data**: never enough, many artifacts, heterogeneous formats
- **time waste:**
  - formatting and manipulating files
  - manual artifact rejection
  - implementing machine learning algorithms for pattern recognition
  - porting from batch to “live” environments for closed-loop experiments

System Requirements



- Easy to program (graphical wiring diagrams)
- Multiple platforms (Mac OS X, Linux)
- Runs on single or multiple machines
- Very fast interactive 2-D & 3-D graphics (OpenGL)
- Support commercial domain packages (e.g. Matlab)
- Seamless transition from batch to streaming processing
- Ability to work with HDF, XML, text, Matlab, and other formats
- Scripts can be run without graphical front-end
- Inclusion of atmospheric forward modeling code for Bayesian inference
- Easy to modify for different scenarios

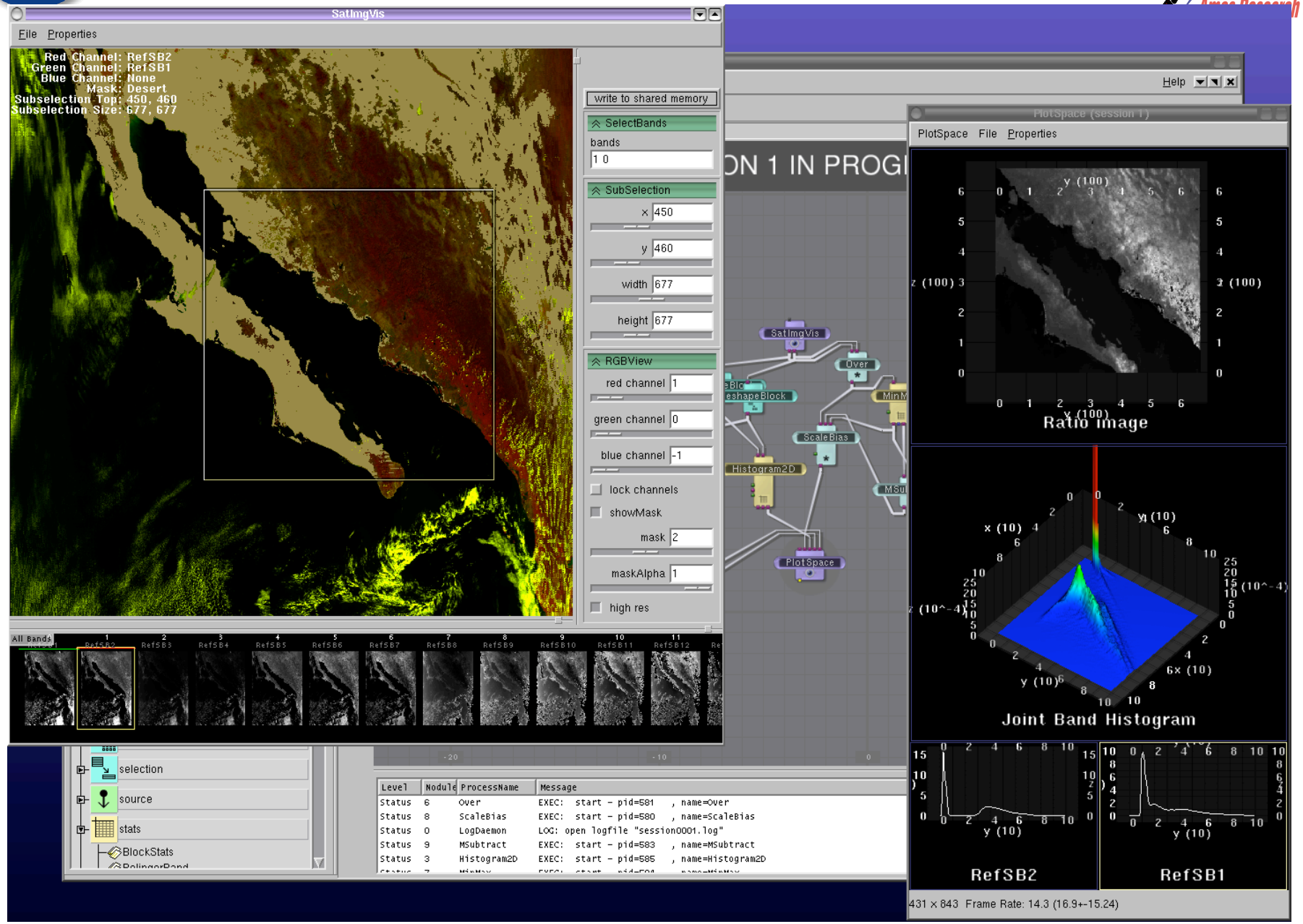
Conclusion



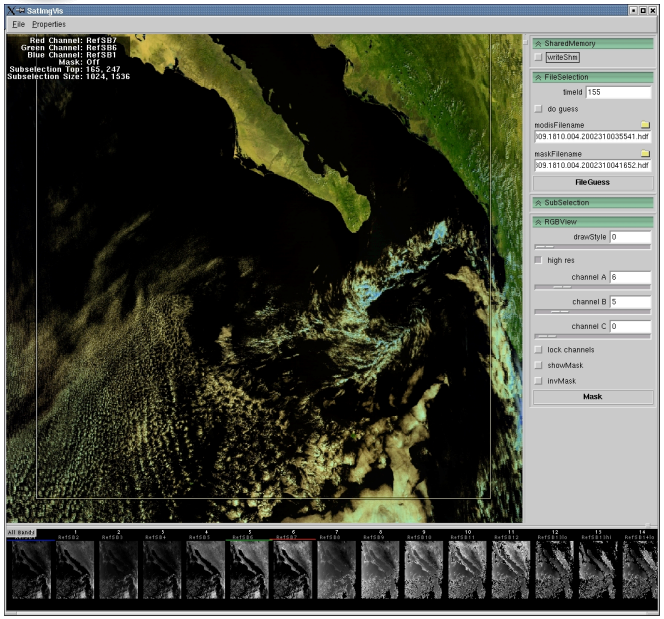
Collaborations & Partnerships

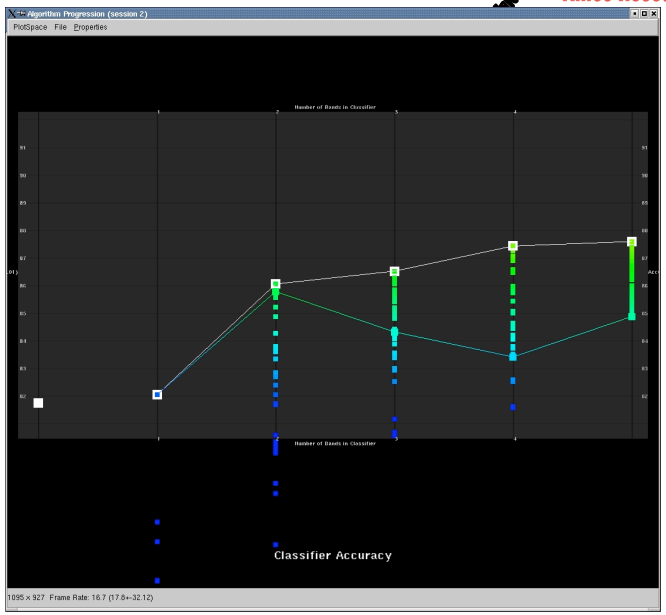
Kevin Wheeler
kwheeler@mail.arc.nasa.gov
www.ic.arc.nasa.gov/projects/ne/ehs.html

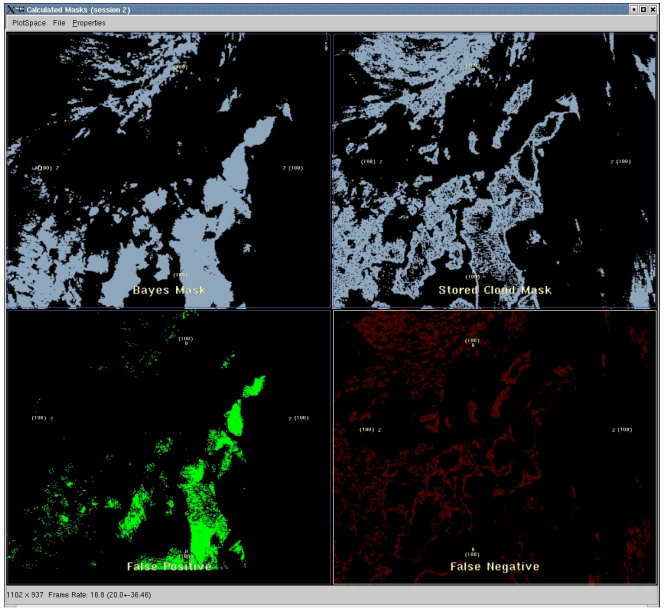
Atmospheric Inference

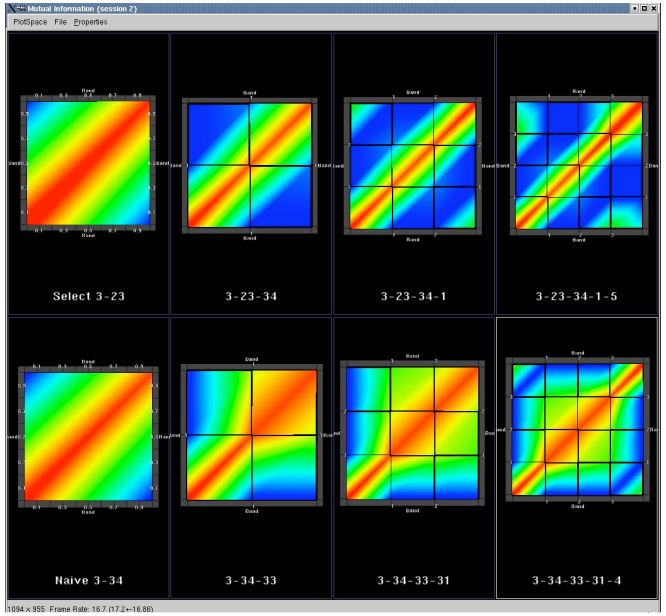


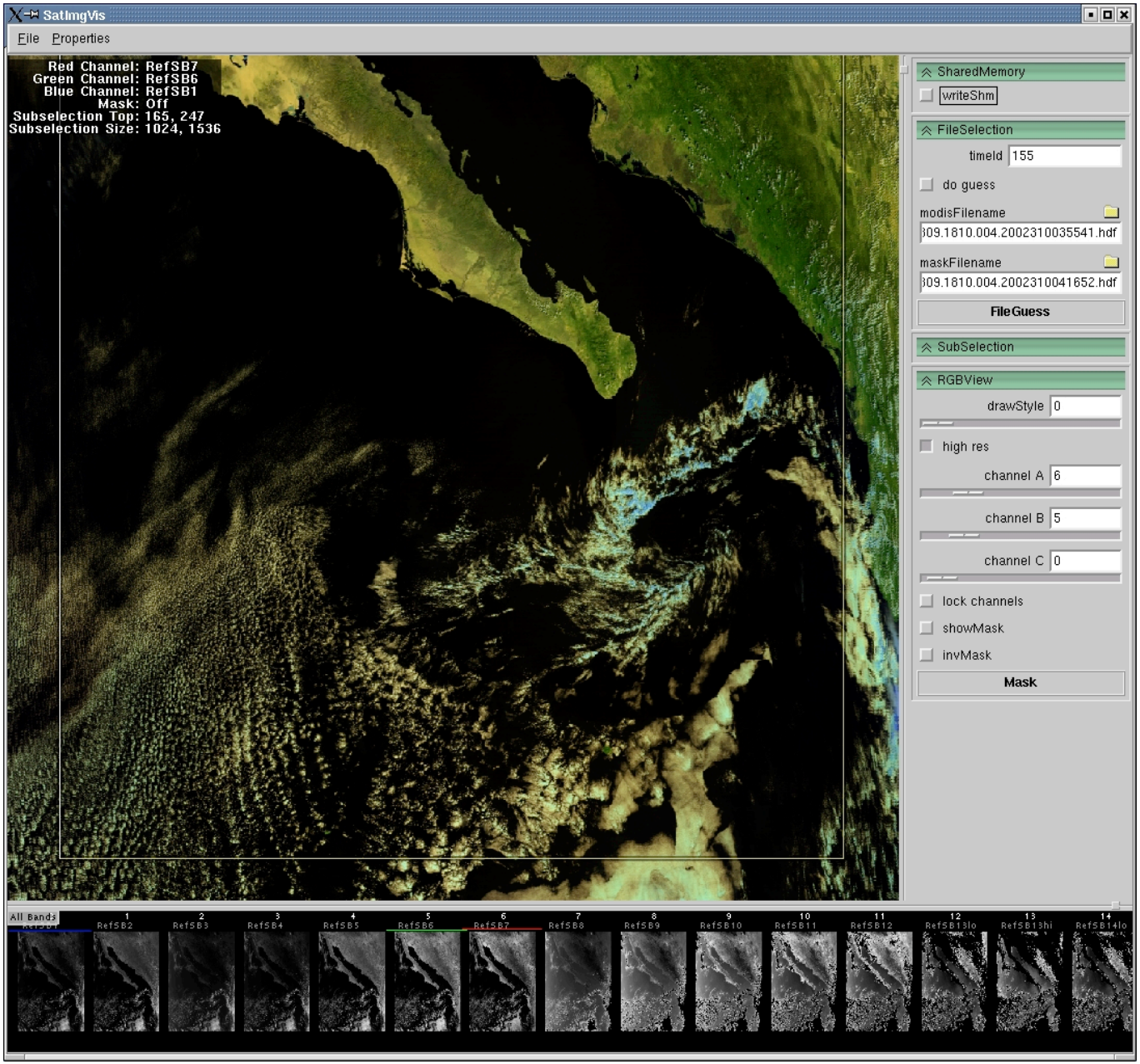
Naïve Bayes Classification










SatImgVis
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Green Channel: RefSB6
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FileSelection
timeId 155
do guess
modisFilename
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maskFilename
309.1810.004.2002310041652.hdf
FileGuess
SubSelection
RGBView
drawStyle 0
high res
channel A 6
channel B 5
channel C 0
lock channels
showMask
invMask
Mask
All Bands
1 RefSB2
2 RefSB3
3 RefSB4
4 RefSB5
5 RefSB6
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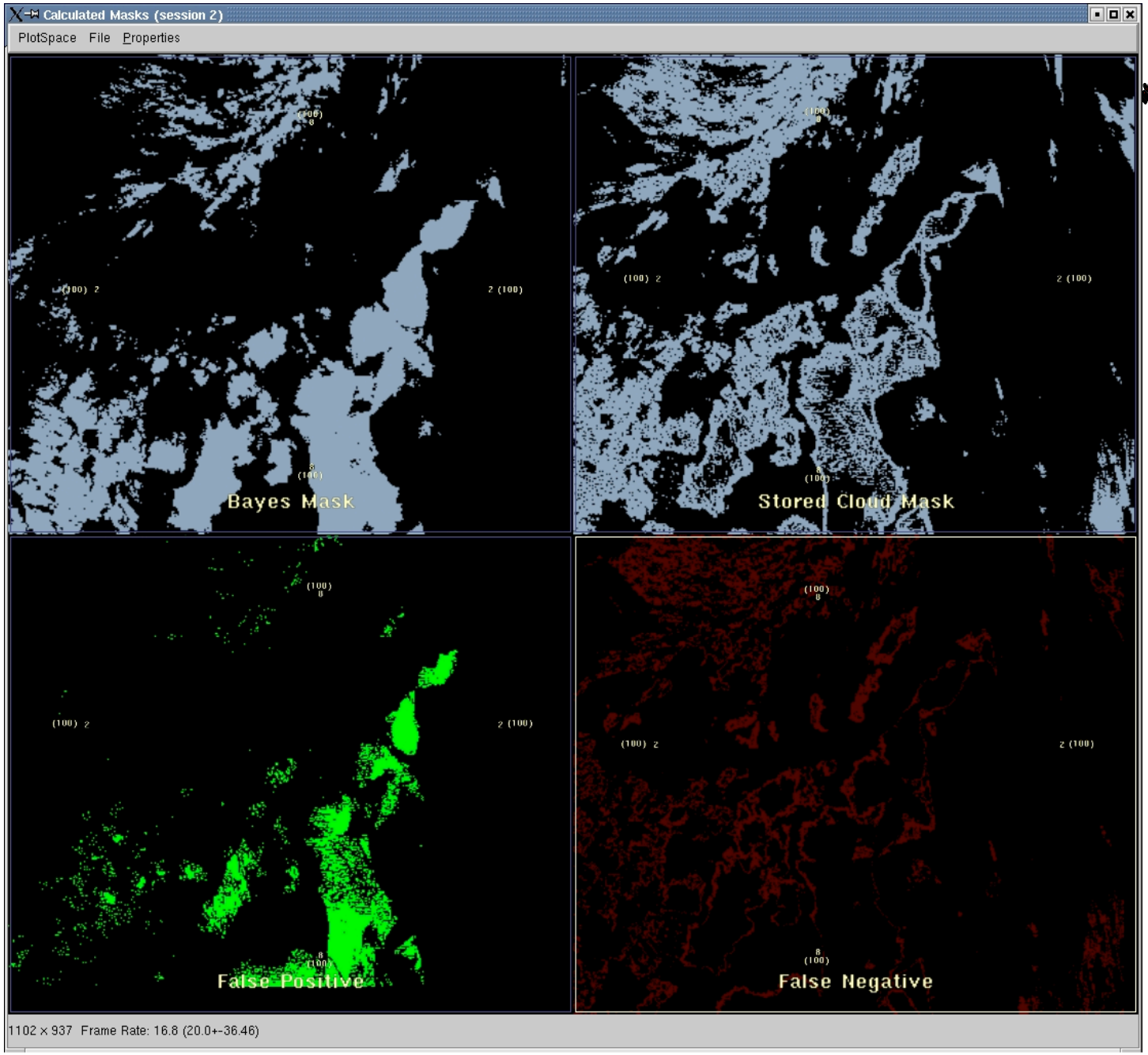
12 RefSB13lo
13 RefSB13hi
14 RefSB14lo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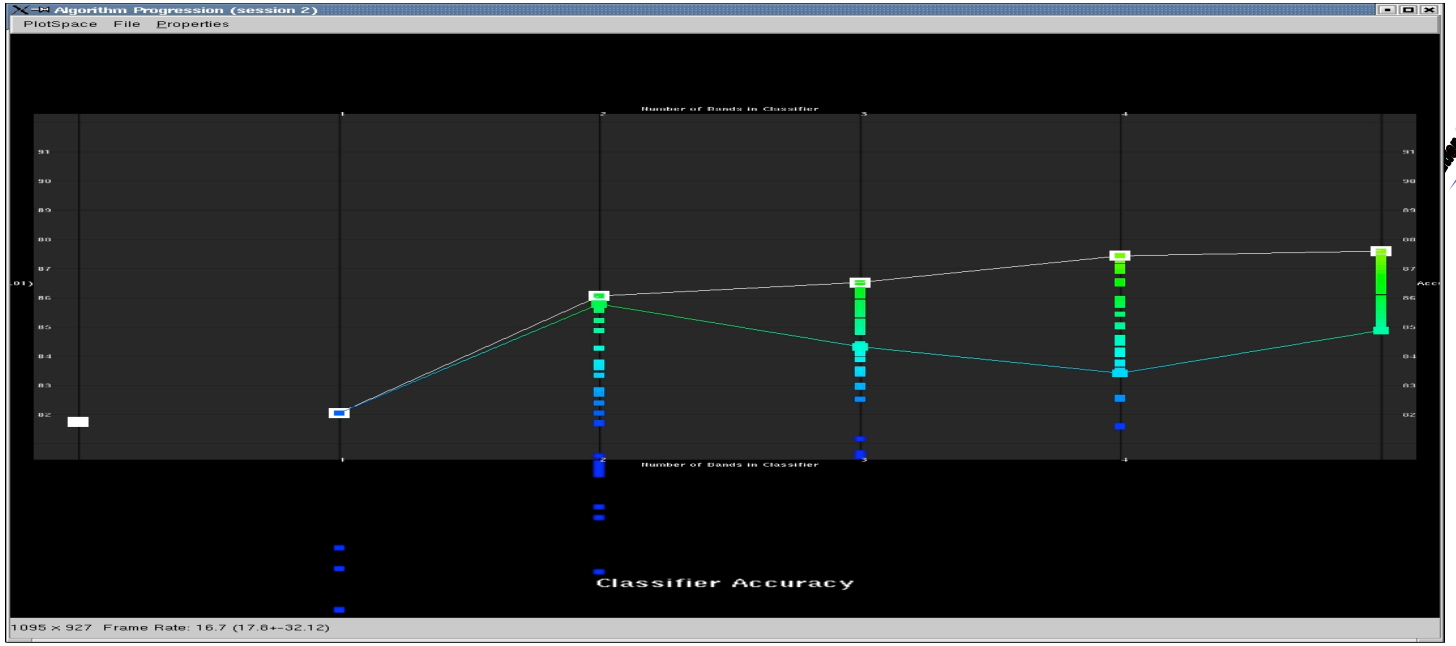
Bayes Mask
Stored Cloud Mask
False Positive
False Negative
1102 x 937 Frame Rate: 16.8 (20.0+-36.46)


Algorithm Progression (session 2)
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Number of Bands in Classifier
Number of Bands in Classifier
Classifier Accuracy
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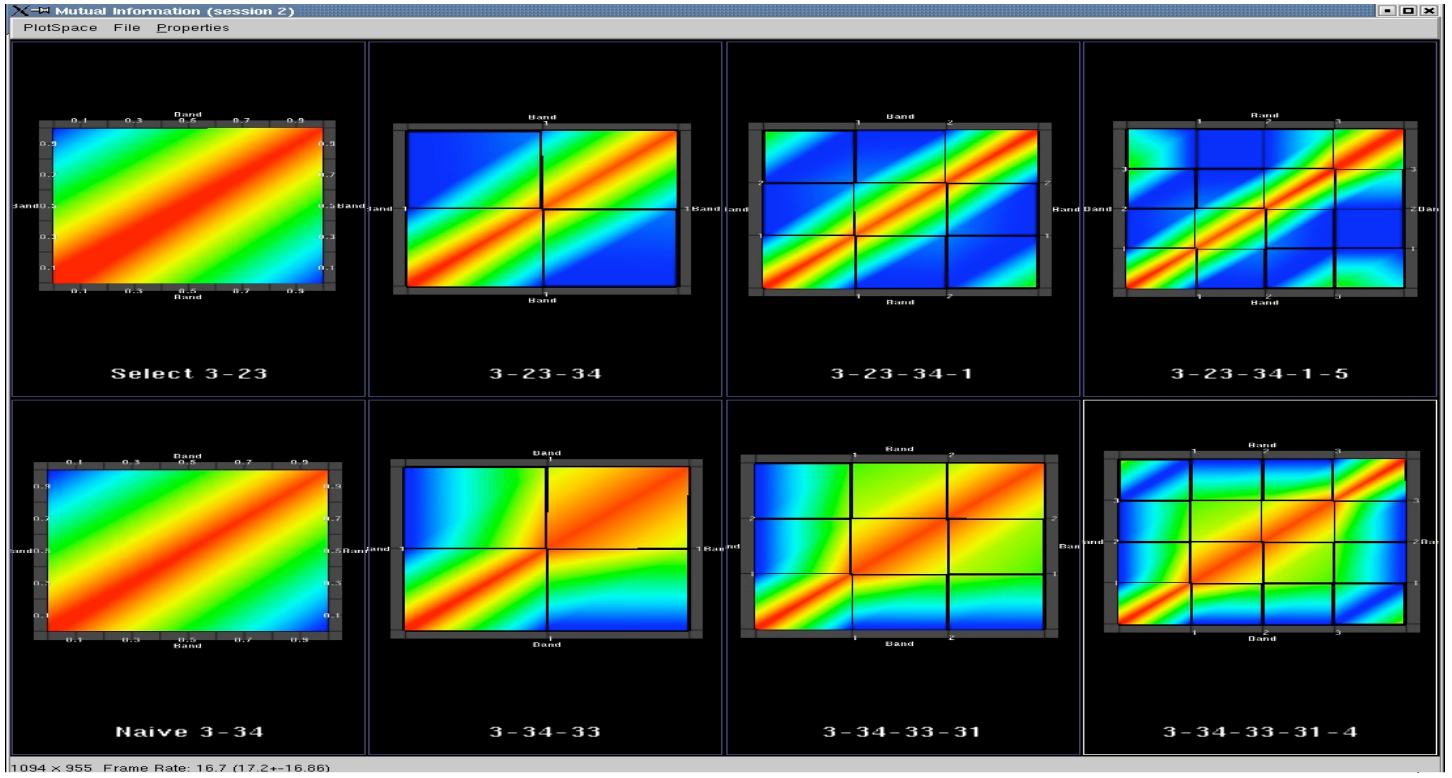
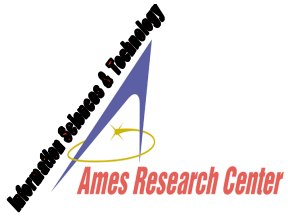

Mutual Information (session 2)
PlotSpace File Properties
Select 3-23
3-23-34
3-23-34-1
3-23-34-1-5
Naive 3-34
3-34-33
3-34-33-31
3-34-33-31-4
1094 x 955 Frame Rate: 16.7 (17.2+-16.86)

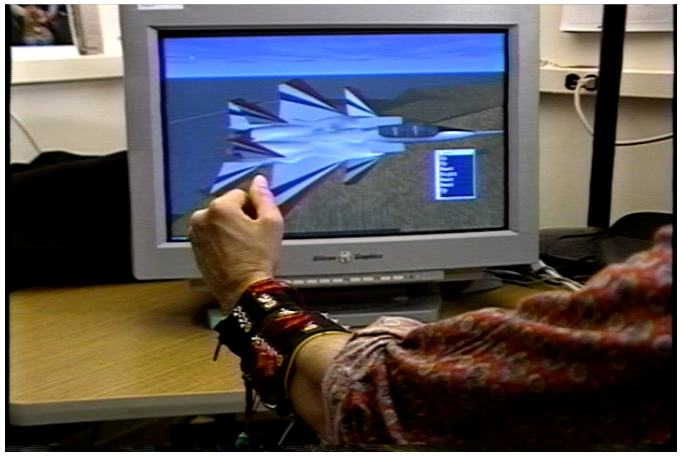
Concluding Goals



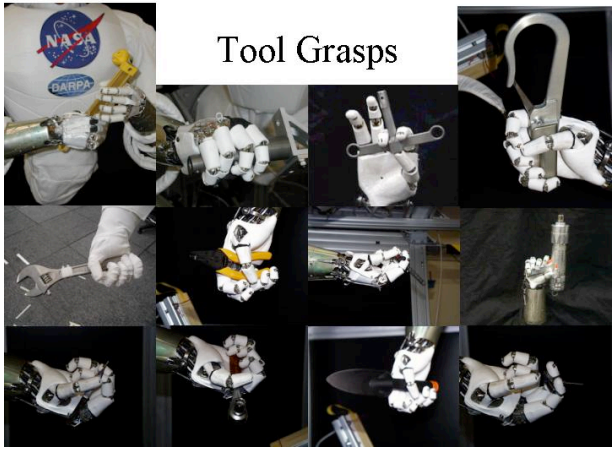
- Collaborations & Partnerships:
  - pattern recognition for streaming data problems
  - providing software framework to partners
  - application of bioelectric interfaces to real-world problem domains.
  - converting from full manual to semi-autonomous control
  - atmospheric inference
  - Bayesian modeling techniques
  - Space based construction

Conclusion

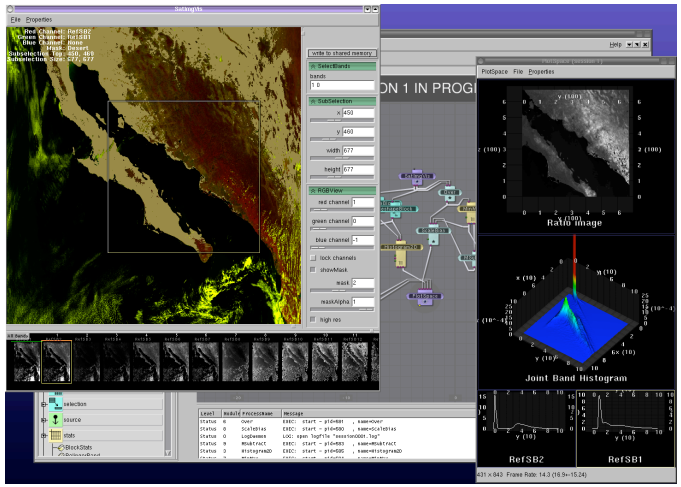
control with gestures



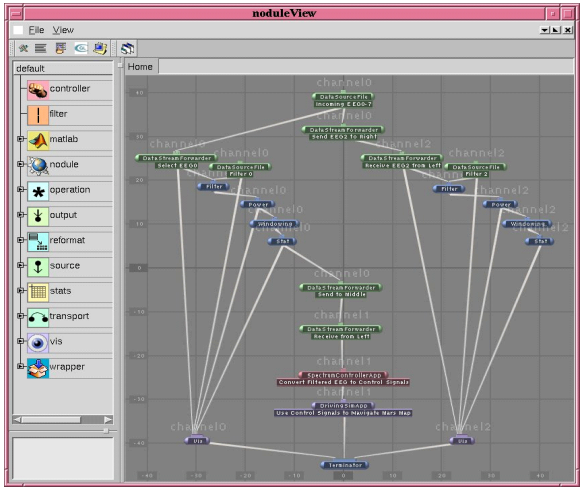
robotic interfaces
semi-autonomy



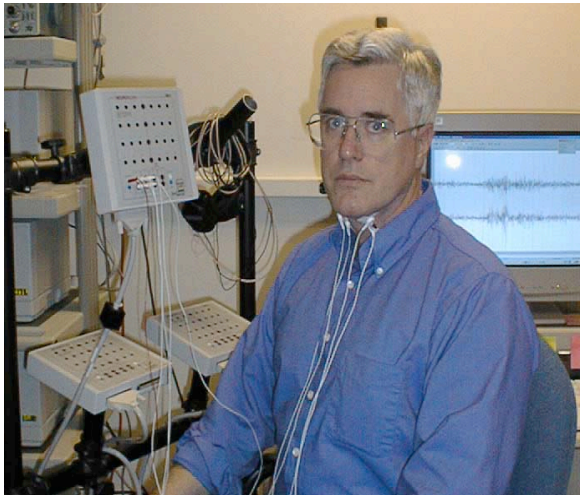
brain computer interfaces



atmospheric inference



streaming frameworks



silent speech